Flying without wings

Dr Steve Coulson and **Professor Natalia Lebedeva**

outline the progress the AVIFauna team has made in understanding and documenting the transit of invertebrate organisms to the remote island of Svalbard under the feathers of migratory birds

Can you offer an update on the progress you have made on the AVIFauna project so far?

SC: The project has been very successful. We have begun to find soil invertebrates on some species of birds and have trialled various methods to catch and remove the invertebrates without harming the birds themselves.

2012 was your second year of research. What were the objectives for this period?

SC: We aimed to continue to develop the field methodologies and gather data. In the summer of 2013 we will use these techniques to target snow buntings and purple sandpiper; two species very likely to transport soil animals to Svalbard during their annual migrations since these are terrestrial ground nesting birds.

NL: The main purpose of the project is to provide proofs of distribution of soil animals by birds to Svalbard and the High Arctic. Therefore, we focused our efforts in 2012 on a study of the feathers of live birds. We chose two very interesting species: the barnacle goose and snow bunting. We investigated the former in Ny-Ålesund, and the latter in Barentsburg.

Have you made any significant findings this year?

NL: In 2011 we tried to find the soil animals on the birds by searching plumage but in 2012 we applied new methods. This led us to success: we found several species of soil mites and springtails in the geese. This was a real success compared with 2011, when we found only one common species of mite and two species of Collembola on live geese. We will continue these studies in 2013.

In parallel, we have studied the composition of invertebrates in soils and nests, as well as the temperature conditions in the soil near and within nests. Temperature was increased by goose laying during incubation and after hatching, when the female goose is sitting on a nest. This changes the thermal conditions for soil animals.

What samples were collected and what were the overall outcomes?

NL: We collected materials on invertebrates in ornithogenic landscapes (bird cliffs, habitats of snow buntings, pink-foot geese near Barentsburg, arctic skua, common eiders and kittiwakes) in soils and nests to study the role of these species in the dispersion of invertebrates.

Interesting data on the temperature conditions in the nests of snow buntings and barnacle geese and cliffs was also obtained.

Invertebrates were extracted from 200 soil samples and nests is made in Ny-Ålesund, Barentsburg and UNIS. 78 samples of invertebrates from pit-fall traps were selected in Barentsburg from different types of bird habitats.

New materials have been used to study the genetic diversity of oribatid mites to clarify the history of archipelago colonisation by

invertebrates. Along the way, we were able to collect data on ectoparasites of snow buntings and barnacle geese with some data obtained for the first time in Svalbard.

Have you concentrated solely on field research?

NL: Not exclusively. Research in Barentsburg was not only conducted in the field, but also in the new laboratory, which was opened in the spring of 2012 by the Murmansk Marine Biological Institute.

As a result of your findings, has your research focus changed or shifted at all?

SC: Yes it has. A smaller project arose from the AVIFauna fieldwork. As part of the determination of invertebrate species potentially imported to Svalbard by bird migration we realised we needed to have some idea about introduction via human activity. This was especially important for the region around Barentsburg where we became aware that soils had been imported from the then Soviet Union for use in greenhouses. This soil had been disposed off around the town and we believed that invertebrates might have been introduced to Svalbard along with this soil.

From these results we also took the opportunity to visit the abandoned Russian town, Pyramiden, in summer 2012 to evaluate the introduced invertebrate species here. We are still working on the samples as it takes a considerable effort to identify these species.

In this case the imported soils were not for use in the greenhouse but rather were spread around the settlement in an attempt to 'improve' the poor thin natural soils and enable the establishment of introduced grasses in order to 'green' the town. Pyramiden was to be a perfect Soviet society; an international flagship if you wish.

What is interesting about the discovery of new invertebrates introduced in Svalbard by imported soils?

SC: Firstly, these are the first records of any human-introduced species into the environment in the High Arctic. Secondly, that some have the potential to become invasive, especially in the nutrient enriched areas beneath bird cliffs. This is a characteristic environment of Svalbard since the soils are usually extremely nutrient-poor. Invasive species here would have the potential to disrupt these fragile habitats.

Does this discovery impact your initial hypothesis?

SC: The identification of this route of entry does not affect the main hypothesis. Invertebrates likely colonised Svalbard after the retreat of the ice starting 10,000 years ago. There are no invertebrates with widespread occurrence outside of settlements that are thought to have been introduced by man. However, it must be recognised that Svalbard has a short history of human habitation. With the exception of a few Pomor hunters from Russia, Svalbard was not visited until the start of the whaling boom (early 17th Century). The arrival of humans in large numbers has only been occurring post-WWII and has recently accelerated with increased tourism and science in the islands.

What are the next steps in achieving your research goals?

SC: One of the next steps is to try sequencing the invertebrates found on the birds, in the Svalbard soils and at locations on the migration routes of the birds. If we can get close matches then the contention that the birds are really important in introducing the soil inverts would be much stronger.

Have you faced any significant challenges during the coordination of these research activities?

SC: Russian customs and bureaucracy have proved challenging. Other than this, we have only had to manage the general complexity of an international project with diverse workers all trying to conduct fieldwork at multiple sites within a six-week field season (from when the ground clears of snow until when the summer season of activity begins to cease) and in a region with very strict nature protection regulations requiring all activity to have a permit.

What preparations are being made for the final phase of the project?

SC: The final field season will involve targeted fieldwork on the geese, snow buntings and purple sandpipers. Furthermore, we will gather invertebrates for use in the sequencing study and hopefully, through connections with other institutions and museums, gather invertebrate specimens of the same species found in Svalbard from other locations to use in the sequencing studies.

We will also take the final soil samples from Pyramiden to analyse for soil type and the presence of pollutants/pesticides to help explain the unusual soil invertebrate communities we are finding in the soil samples from 2012.

NL: We will do a lot of work in the laboratory to describe the results and gather new data from live birds. A lot of hard work awaits us in 2013. We must focus on genetic research of soil mites from different substrates (birds' feathers and soils), and on the study of the conditions for soil animals that are formed in the plumage of birds.

Ultimately, by studying microscopic fungi, we will try to answer questions of whether there is sufficient food for these soil animals and how long they are able to survive in the plumage of the birds.

Microscopic **migrants**

After an exciting year, *International Innovation* catches up with the **AVIFauna** project, an international study exploring how migratory birds have introduced invertebrate fauna, including insects and mites, to the small and remote Norwegian archipelago of Svalbard

OVER 400 MILES from the northernmost tip of mainland Europe stands Svalbard, an archipelago located in one of the more inhospitable regions of the planet. Though biodiversity is limited on this beautiful but remote island, the life forms that do inhabit it alongside its 2,500 human residents are often highly abundant, and it is the summer destination for thousands of migratory birds.

For the last two years, a group of researchers from Norway, Russia, Poland and The Netherlands have joined forces in an attempt to document and understand the migration of invertebrate organisms – including insects and mites – to this most remote destination. Invertebrates play a vital role underpinning many ecosystem functions such as nutrient cycling and the formation of organic soils required by plant life. All invertebrate life in the archipelago was seemingly exhausted tens of thousands of years ago in the last glacial period, but the islands now find themselves alive with over 1,000 species of terrestrial and freshwater invertebrates on and around the island, leading researchers to question how they arrived there.

The Avian Vectors of Invertebrate Fauna' (AVIFauna) research team is interested in the role that birds have played in introducing such organisms to the island and, through dedicated study, they have made some discoveries that could provide the answer.

HITCHING A RIDE

When presented with the question of how invertebrate fauna have arrived on Svalbard, the researchers hypothesised that invertebrates could have used phoresy – a zoological term which essentially describes the transit of one organism by another more powerful one. The theory originally raised eyebrows in some quarters of the ornithological world, with some experts sceptical that such creatures would make such a long and perilous journey hidden away under the feathers of birds. Proving the existence of this relationship is the main basis for the project.

DIGGING DEEPER

Svalbard's long, harsh winters mean very few birds are able to survive there during those months but during the summer it homes a number of different migratory species, including geese, eiders, waders and sandpipers. After a cautiously successful first period of research during the summer of 2011, the AVIFauna team has revised its methodology, leading to some interesting findings during the second phase of fieldwork.

Compared with 2011, when they had literally been scratching the surface of the birds' feathers to see what was underneath, in the past year, the project has focused on analysing the barnacle goose

CONTENTS OF A PITFALL TRAP SET TO COLLECT SURFACE ACTIVE INVERTIBRATES

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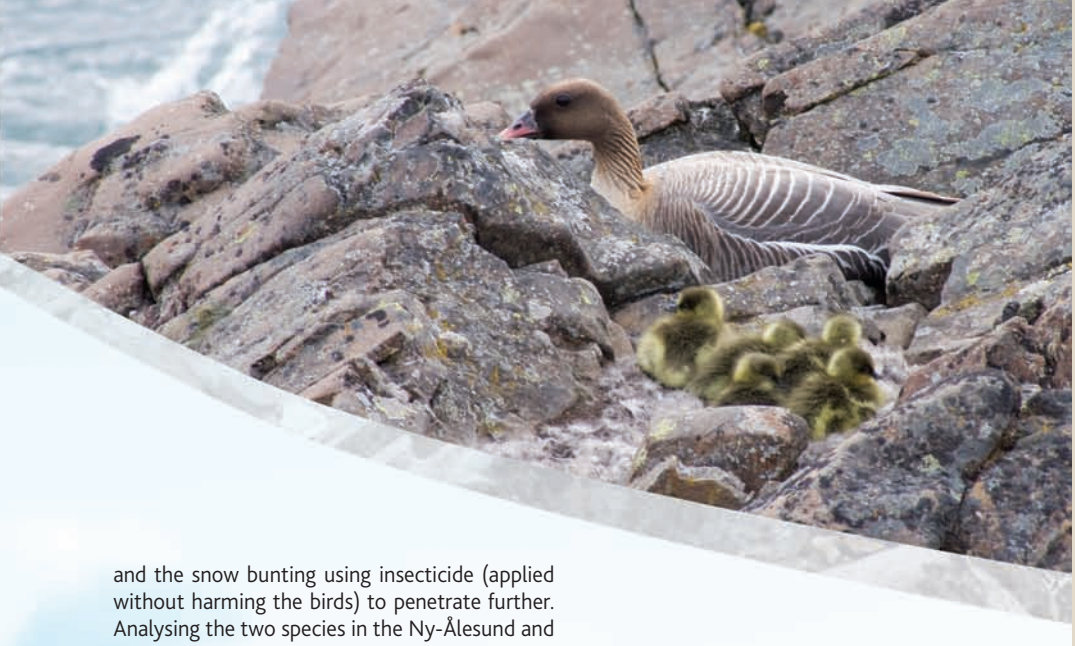

and the snow bunting using insecticide (applied without harming the birds) to penetrate further. Analysing the two species in the Ny-Ålesund and Barentsburg regions respectively, the researchers found success almost immediately, discovering several species of soil mite and springtails hidden within the birds' feathers.

IN THE GENES

In addition to the live bird research, AVIFauna are analysing soil samples from across the island to clarify the history of archipelago colonisation by invertebrates. To understand and document this, the group has extracted over 200 samples from soil, nests and invertebrate pit-fall traps from across the island. In order to analyse the origin of invertebrate species, the group is involved in comparing the DNA sequences from the invertebrates found in Svalbard and invertebrates form the migratory bird's point of origin. If the DNA sequences match, the team will have successfully proved their theory. The scientists will then potentially be able to physically map and track the migration of species to the island – something that has never been done before.

In understanding and documenting these creatures the researchers are benefiting from access to the Murmansk Marine Biological Institute laboratory, a new facility which opened in spring 2012. They have also utilised the skills and expertise of specialist taxonomists to rapidly identify and classify any species the team collects. It is a highly involved piece of work, with the 2013 'Barentsburg Invasion' paper itself having 13 co-authors from eight countries. Encouragingly, the involvement of such a range of specialists has resulted in the publication of a number of complementary research papers – furthering scientific knowledge in a number of areas.

One example of the group's stellar work is the gamasid mite. The gamasid mite community of Svalbard is amongst the best known of invertebrate groups on the archipelago due to recent revisions in knowledge of the species based on fresh sampling campaigns. In spite of this, members of AVIFauna were able to identify a hitherto unrecorded species of gamasid mite found along the strandline in Barentsburg. This finding brings the total gamasid mite inventory of Svalbard to 29 species, although the present one is littered with synonyms and misidentifications. Nevertheless, resolving these confusions and maintaining an accurate and updated species inventory is of prime importance in understanding the ecology of this region, especially in a period of rapid environmental change.

HUMAN IMPACT

The study has proven to be both dynamic and responsive; its focus extending beyond the initial pioneering research on migratory birds to incorporate a sub-project concentrating on the potential human impact and influence on invertebrate population. The team is keen to investigate the number and types of invertebrate that may have unwittingly been transported to the island by humans and assess the potential of the introduced species to become invasive, documenting it in the final report.

The summer season in Svalbard allows researchers a brief, six-week window in which to conduct their work. Undertaking research in such an unforgiving environment has posed many challenges, of which logistics was only one, as Coulson explains: "Fieldwork in the High Arctic can be logistically difficult, but in addition, we are working in a unique and vulnerable protected area; as a result, all field activities require permission from the Governor as well as other national regulatory bodies". This is a challenge that will continue.

Working with Russian bureaucracy has also proven taxing to Coulson's colleagues and is something that the pan-European team is working hard to accommodate in order to limit the effect it has on the research.

To date, the project has already seen the publication of numerous research papers across Europe which have been well received. It has also opened up new avenues and opportunities for research which the team is keen to explore in the future. With a little over a year to go and one short summer left, the group is now well on their way to demonstrating one immigration route for the invertebrate population of the archipelago of Svalbard.

INTELLIGENCE

AVIFauna

AVIAN VECTORS OF INVERTEBRATE FAUNA

OBJECTIVES

To describe and quantify the role of avian phoresy in the dispersal and colonisation of high latitudes by soil invertebrates which are not normally considered to be phoretic, primarily oribatid mites and Collembola.

KEY COLLABORATORS

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STEVE COULSON received his PhD in insect ecophysiology from the University of Leeds, UK, in 1991. He spent periods at Liverpool John Moores University and the University of Oslo before starting work as an Associate Professor at the University Centre in Svalbard (UNIS) in 2005.

NATALIA LEBEDEVA received her PhD in Zoology in 1990 in Ecology from the Severtsov Institute of Problem Ecology and Evolution in Moscow, Russia. She worked in Rostov State University as Full Professor, and then as leading scientist in Murmansk Marine Biological Institute. Since 2000 she has studied distribution of soil microarthropod in the Arctic by birds.

UNIS